Project No. PB-2 Boron deficiency and Toxicity in almond
Project Leader: Patrick Brown, UC Davis
Cooperating Personnel: Agnes Nyomora and Farm advisors

Objectives Summary:

1 -To optimize the commercial rate of B application in almond.
2 -To determine the optimal time of B foliar application.
3 -To determine the appropriate tissue and sampling time for boron diagnosis.
4- To assess the effect of rootstocks and cultivars on boron accumulation, tolerance and or resistance to boron deficiency and toxicity.
5- To determine the effect of tissue B concentration on tree response to foliar B application.
6- To study the effect of yield on hull B concentration.

Results

Objective No.1- Optimization of the commercial rate of B application in almond.

The experiment was initiated in September,1996. Five rates 0, 1, 2, 3, and 5 lb Solubor/100 gallons of water equivalent to 0, 245, 490, 735 and 1225 ppm B as well as 2 rates of Borosol at 245 and 490 ppm B were applied to 15 years old Nonparel/Carmel/ almond Orchard in Modesto, Stanslaus County. Applications were made to 0.2 acre blocks using a commercial speed sprayer at the standard 100 gallon/acre rate. Results will be determined in Spring and at harvest in 1997.

Objective No.2- Determination of the optimal rate and time of B application

Five rates of applications i.e. 0, 1, 1.5, 2, 2.5 lb solubor/100gal, equivalent to 0, 245, 368,490, 613 ppm B were tested on 10 year old Butte' trees alternated with Carmel' and Peerless' pollinizers. Applications were made by handgun sprayer at a rate of 4 gallon/tree equivalent to 400 gallon/acre. Three dates of application namely early hull split (12 August), postharvest (27 September) and late bud swell (15 February) were tested in 1994/95 and 1995/96 in Orland, Glen County. Fruit set and yield data were available from all the treatments only during 1995/96 season. B concentration in almond buds sampled in February was highest in trees treated during bud swell in February (1996), followed by postharvest (September 1995) and hull split (August 1995) respectively (Table 1) thus, the later the B treatment, the higher the B concentration in the buds. Bud B concentration increased significantly with increasing rates of foliar applied B when applications were made in February. Only the highest rate of application significantly increased the bud B concentration of trees treated in August while no significant difference in bud B concentration due to rates of application was observed from trees sprayed in September.

Fruit set responded positively to increased B application at all application dates. Set increase of as much as 40% were observed with the highest rate of B application

when applied in August or February. Though an increase in set percentage is a necessary precursor to increased yield, other unknown factors may ultimately determine the percentage of set fruit that remain on the tree at harvest. Foliar B sprays clearly result in increased fruit set and hence provide the potential for increased field.

When applications were made in September and February, yield expressed as weight and number of nuts/tree increased with increasing B concentration in the spray solution and was maximal at 2.5 lb (Table 1). In contrast, B application in August at 2.5 lb solubor/100 gallon resulted in yields equivalent to unsprayed trees and 25% less than trees sprayed with 1.5 lb solubor /100 gallon. This could indicate that higher doses of B are required when applications are to be done during post harvest or bud swell in September and February, respectively (Table 1) while lower doses of B are required when application is to be made before harvest. In a similar experiment in Fresno during the 1993/94 season, postharvest application (30 September) was more effective in increasing the tissue B concentration and yield than winter (dormant buds in December) and spring (early popcorn buds in late February) applications. This year's results differ from the earlier observations from Fresno. This may have been due to differences in flower development at the two stages. Regardless of the cause, there is clearly a need for replication of this experiment.

Objective No.3- To determine the appropriate tissue and sampling time for boron diagnosis.

Detailed sampling of the leaves, buds and fruits have been conducted and will be compared with yield in 1997.

Objective No.4- Assesment of the effect of rootstocks and cultivars on boron accumulation.

This experiment was conducted at Nickles Farm in Arbuckle on a 21 year old almond orchard. Nonpareil' was used as the test cultivar. Results in 1995 demonstrated that almond grown on peach- almond hybrid rootstocks (Bright's hybrid and I-82) accumulated significantly less B in hulls than those grafted on rootstocks Nemaguard' and Marianna'. The overall B concentration in the orchard was marginal and similar in both years (less than 100 ppm). In this years trial, hull B concentrations were generally lower than in 1995 and there was no significant difference in hull B concentrations between Bright's hybrid' , 'I-82', Lovell' or Marianna'. Trees grown on Hansen536'almond peach, or almond rootstock had significantly lower hull B concentration. Lovell' and Marianna' had significantly lower yield than I-82', Hansen' and Bright's hybrid' in that order '(Table 2).

Objective No.5. Determination of the effect of tissue B concentration on tree response to foliar applied B

This objective will be completed upon collection and analysis of cumulative data of the last 4 years in addition to the data to be collected in 1997. This is an ongoing experiment.

Objective No.6. Effect of yield on hull B concentration.

Inadequate pollination at U.C.Davis and toxic B levels in Capay valley test orchards prevented completion of the experiment. This experiment needs to be conducted in an orchard having adequate B content and potentially high yielding. We are currently locating a suitable orchard for 1997 trials.

Conclusion.

Experiments conducted to date show that B application significantly improves fruit set and final yield of almond and that these positive yield responses occur in trees that do not show vegetative B deficiency symptoms. This implies that many Californian orchards grown in sandy soils could be suffering incipient B defiency. In addition to confirming the optimum time and rate of B application, statewide surveys of almond orchards is needed to determine the extent of the problem. Our experiments during 1994/95 suggested that the almond hull may be an appropriate tissue to determine the B status of the tree. Our efforts to verify this finding in 1996 was compromised by unusual weather conditions and an inadequate experimental site. There is a need to repeat this experiment since we now know that current diagnostic analysis based on leaf analysis is inadequate. There has been very widespread adoption of foliar B application. Many growers and PCA's have seen measurable yield increases. Questions remain as to optimum rates, timmings and tissue diagnosis. There is a clear need to resolve these outstanding issues to ensure this technology is used appropriately.

Table 1: Effect of the time and rate of foliar B application on bud B concentration, initial fruit set and yield of almond cv Butte

Time	B rate (lb/100 gal)	Bud B conc. (ppm)	Fruit set (%)	Yield/tree Weight (kg)	Yield/tree No. fruit
Hull split (Aug)	0	75a	34a	21	5825
	1.0	83a	38a	25	7270
	1.5	81a	44ab	27	7643
	2.0	89a	42ab	23	6855
	2.5	126b	46b	21	5981
	0	81a	30	25	6736
	1.0	92ab	34	25	7142

Postharvest (Sept)	1.5		94ab		32		26	7378
	2.0		99ab		41		28	8213
	2.5		102b		39		29	8848
	0		75a		42a		27	7503
	1.0		111a		46a		26	6970
Bud swell (Feb)	1.5	138a		50a		26	6946	
	2.0		143ab		50ab		27	7146
	2.5		161a		58b		31	9027

Means with the same letter within a column and date are not significantly different according to Fisher Protected LSD (P=0.05)

Table 2: Effect of rootstocks on tissue B concentration of almond cv ‘Nonpareil'

Rootstock	Nutmeat (Kg/tree)	B concentration (ppm)
Hansen536	24 a	560 b
I-82	25 a	72 a
Bright's hybrid	24a	74 a
Mission almond	21 ab	58 b
Nemaguard	20 ab	72 a
Lovell peach	17 b	65 ab
Marianna	17 b	61 ab

Means with the same letter within a column are not significantly different according to Fisher Protected LSD (P=0.05)

Table 3: Effect of crop load on hull B concentation (ppm) of almond cv Butte'

Time	Tissue	Treatments (Fruit load)			
		Control	Low	Medium	High
Before thinning (April)	Leaf	46	54	55	55
	Hull	177	191	182	159
After thinning (August)	Leaf	46	47	41	47
	Hull	340	318	366	357